
# MLS Overview: Instrument Performance and Data Products

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**Aura Science Team Meeting**

**The Hague, Netherlands**
**8 November 2005**

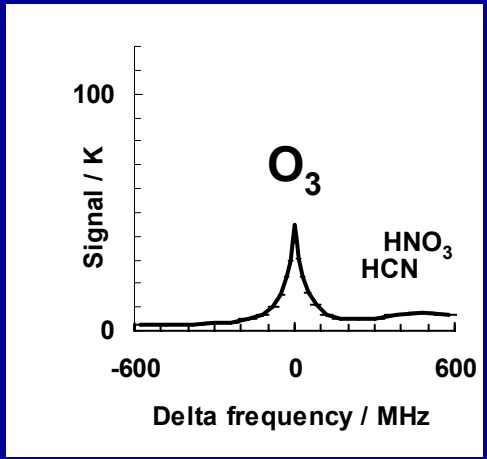
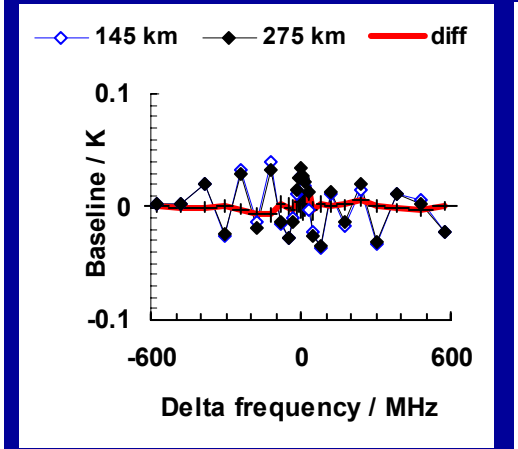
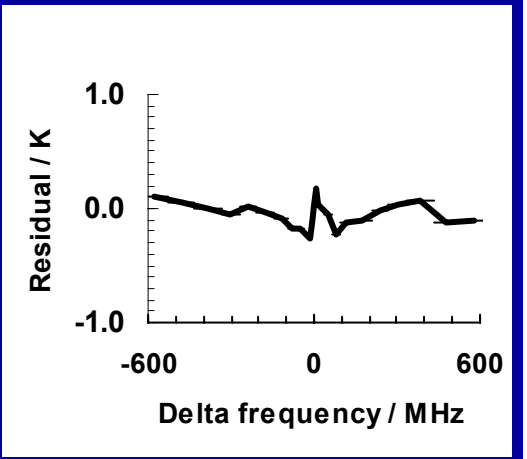
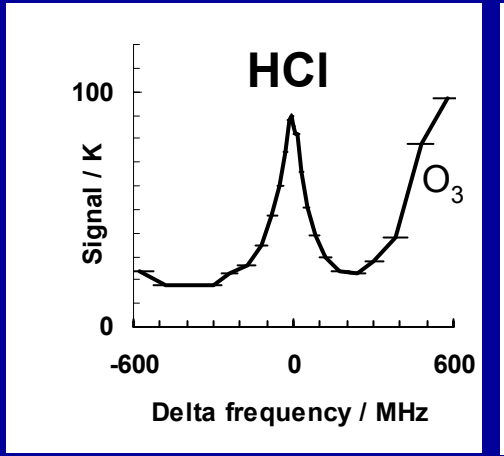
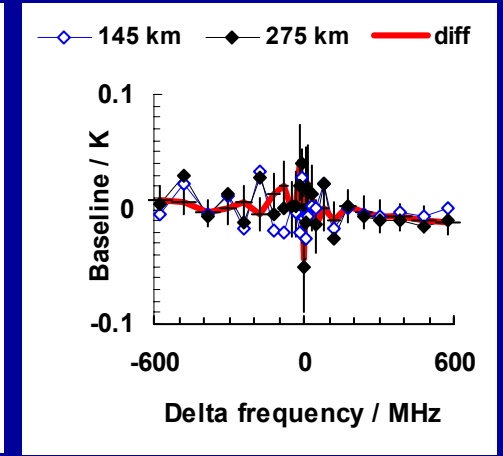
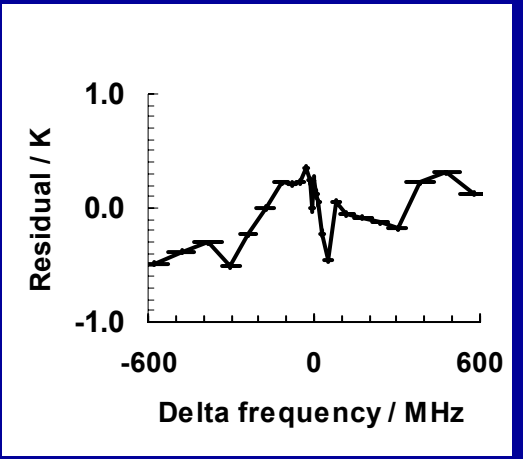
# MLS major milestones since launch

- Began full-up science observations ..... 13 Aug 04
- Began production processing with updated Version 1.51 algorithms ..... 28 Jan 05
- Began making V1.51 Level 2 data publicly available ..... 15 Feb 05
- Released MLS Data Quality Document for V1.51 ('required reading' for data users) ..... 1 Aug 05
- Completed V1.51 reprocessing of all 'old' data, (continue processing all new incoming data) ..... 25 Oct 05
- Goal for beginning production processing with Version 2 algorithms ..... Aug 06

# MLS Instrument Performance

- **Instrument performance has been excellent overall**
  - In full-up science mode since 13 August 2004
  - No major problems have been encountered
- **Calibration accuracy is ~1% for the GHz bands and ~2% for the THz bands, documented in IEEE papers:**
  - Jarnot, et al.: GHz radiometric and spectral cal & performance
  - Cofield and Stek: GHz field-of-view cal & performance
  - Pickett: THz cal & performance
- **Following chart shows examples of performance**

# Instrument Performance Examples and Level 2 Retrieval Residuals

| | Measured Signal (at 26 km tan ht) | Baseline Artifact (1000x scale of signal) | Retrieval Residuals (100x scale of signal) |
|---|---|---|---|
| 206 GHz $O_3$ (band 6) |  |  |  |
| 626 GHz HCl (band 13) |  |  |  |













Vertical bars (not visible in most cases) give the predicted noise for the averages shown here
Equivalent integration time is ~10 minutes for signal and residual, ~1 hour for baseline

# MLS Daily Ops Calendar: 13 Aug 04 – 31 Oct 05

- **Colors show fraction of total time each 24 hours that has good data from all MLS spectral bands**
  - 94% since start of science ops on 13 Aug 04
  - 98% since instrument ops stabilized on 11 Dec 04
- **All data processed through Level 2 for all products**

| |
|---|
| >99% 100% |
| 90-99% |
| <90% (planned) |
| <90% (MLS ops problem) |

| | Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|---|
| Aug'04 | 1 | | | | | | |
| | 8 | | | | | 13 | 14 |
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | 29 | 30 | 31 | 1 | 2 | 3 | 4 |
| Sep'04 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| | 26 | 27 | 28 | 29 | 30 | 1 | 2 |
| Oct'04 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Nov'04 | 31 | 1 | 2 | 3 | 4 | 5 | 6 |
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| | 28 | 29 | 30 | 1 | 2 | 3 | 4 |
| Dec'04 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| | 26 | 27 | 28 | 29 | 30 | 31 | 1 |

| | Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|---|
| Jan'05 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| Feb'-05 | 30 | 31 | 1 | 2 | 3 | 4 | 5 |
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| Mar'05 | 27 | 28 | 1 | 2 | 3 | 4 | 5 |
| | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| | 20 | 21 | 22 | 23 | 24 | 25 | 26 |
| | 27 | 28 | 29 | 30 | 31 | 1 | 2 |
| Apr'05 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| May'05 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | 8 | 9 | 10 | 11 | 12 | 13 | 14 |
| | 15 | 16 | 17 | 18 | 19 | 20 | 21 |
| | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| | 29 | 30 | 31 | 1 | 2 | 3 | 4 |

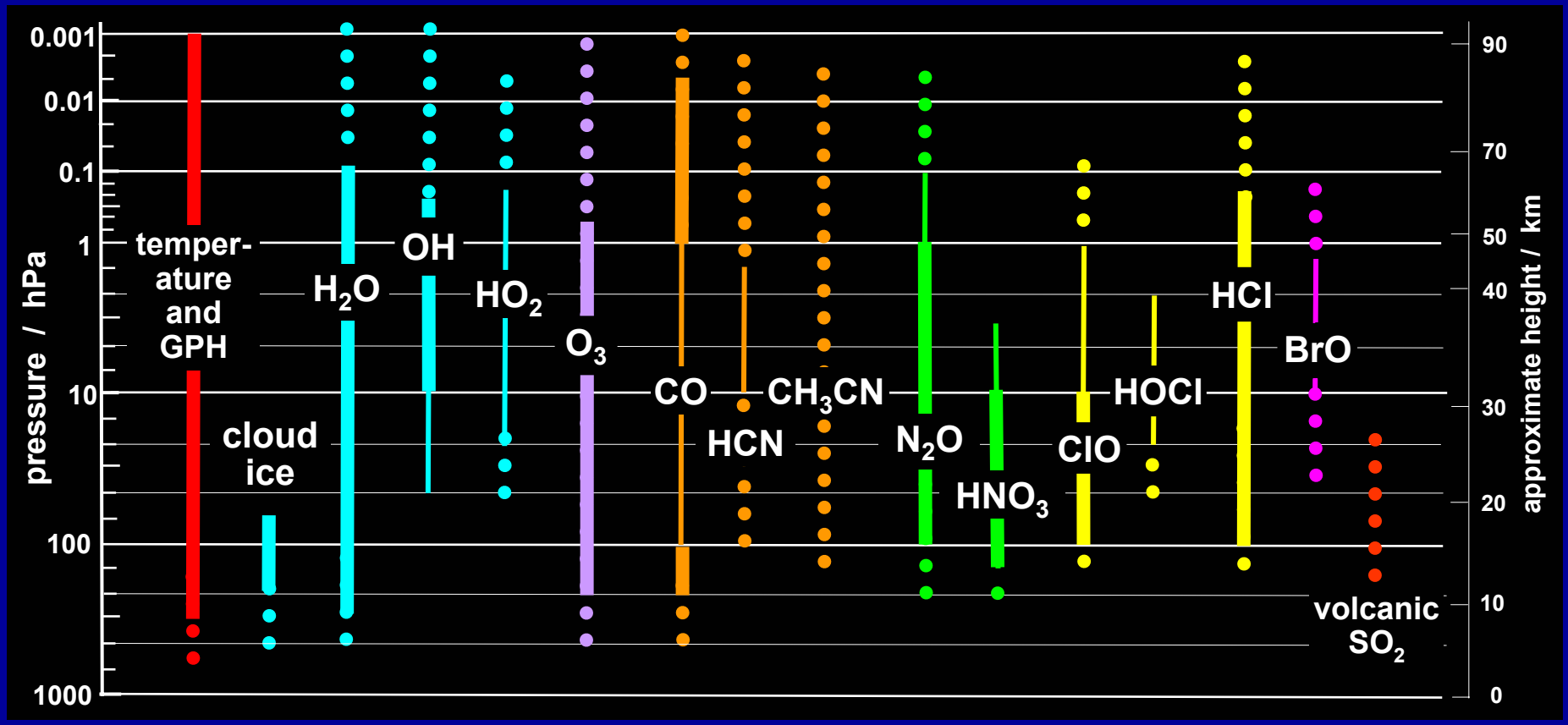
| | Sun | Mon | Tue | Wed | Thu | Fri | Sat |
|---|---|---|---|---|---|---|---|
| Jun'05 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| | 26 | 27 | 28 | 29 | 30 | 1 | 2 |
| Jul'05 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| Aug'05 | 31 | 1 | 2 | 3 | 4 | 5 | 6 |
| | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
| | 28 | 29 | 30 | 31 | 1 | 2 | 3 |
| Sep'05 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
| | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| | 25 | 26 | 27 | 28 | 29 | 30 | 1 |
| Oct'05 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
| | 23 | 24 | 25 | 26 | 27 | 28 | 29 |
| | 30 | 31 | | | | | |

# MLS Geophysical Data Products

**Lines are for V1.51 data, where thin lines indicate averages are always needed**

**Standard vertical grid for V1.51 is 6 per decade P for P > 0.1 hPa,**
**3 per decade for P < 0.1 hPa, and cloud ice has 12 per decade P**

**Dots indicate goals for future versions of data**



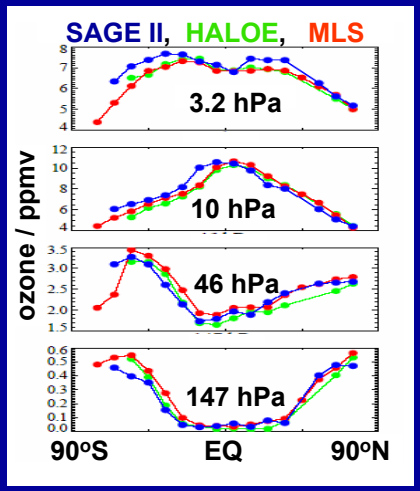

- **MLS data quality document should be read & understood before using data**
- **Register at http://mls.jpl.nasa.gov to receive updates of information on data**

# MLS V1.51 Data

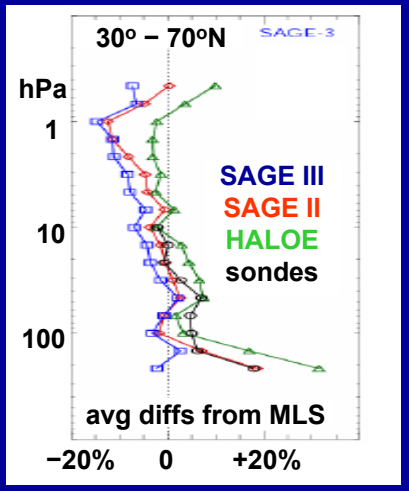
- **All MLS V1.51 data products are publicly available for the entire Aura mission to date**
  - from http://disc.gsfc.nasa.gov/data/dataset/MLS (GSFC DAAC)
- **First phase of data validation has been completed**
  - Overview for T, $O_3$, $H_2O$, HCl, $N_2O$, $HNO_3$, and CO are in Froidevaux, et al., 'MLS Early Validation' paper, IEEE Aura issue, in press.
    - preprint available from http://mls.jpl.nasa.gov (MLS web site)
  - Additional validation results are in presentations given at the September 2005 Aura Data Validation meeting
    - available at http://avdc.gsfc.nasa.gov (Aura Validation Data Center)
- **Following charts give some representative examples of data**

# MLS $O_3$ data

- **Many comparisons of stratospheric $O_3$ have been made**
  - MLS generally agrees to 5-10% with other validated accurate data sets
  - Some examples are at right
  - Slope of MLS differences with height is under investigation

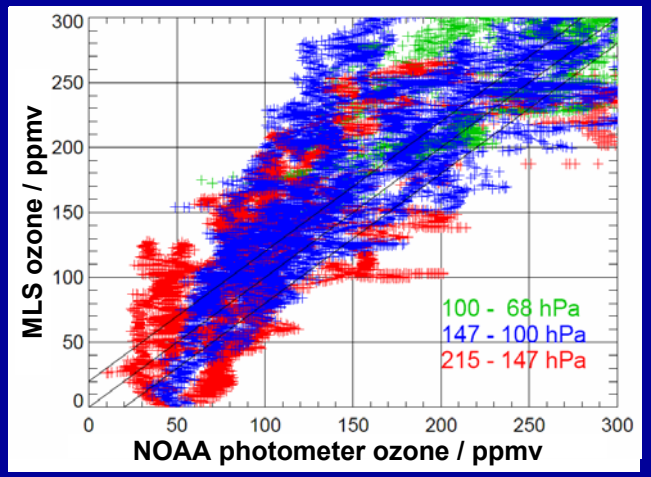



Froidevaux, et al.
IEEE, in press




Ray Wang, et al.
Sep 05 Aura Val

- **Fewer comparisons of tropospheric $O_3$ have been possible**
  - Plot at right shows MLS $O_3$ at 100, 147, and 215 hPa scattered against co-located AVE aircraft measurements made with NOAA photometer
  - These, and other comparisons, suggest that MLS V1.51 UT $O_3$ has a scaling error of ~ +25% and a bias of ~ +50 ppbv

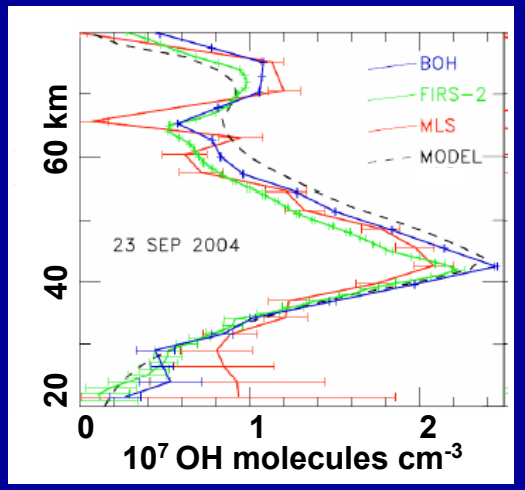



Mark Filipiak, Sep 05 Aura Val

# MLS OH data

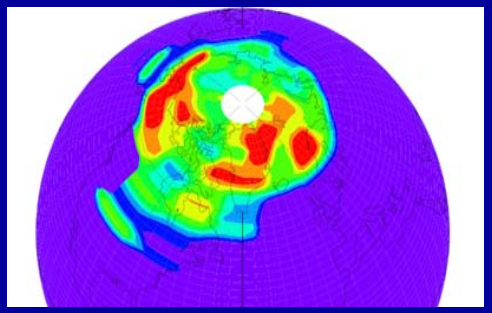
- **MLS OH (and $HO_2$) and correlative balloon measurements agree to within error bars**
  - MLS observations show no evidence for the "$HO_x$ dilemma" seen by MAHRSI
  - See Pickett et al. GRL paper, and Salawitch et al. poster this meeting

MLS, balloon, model comparisons



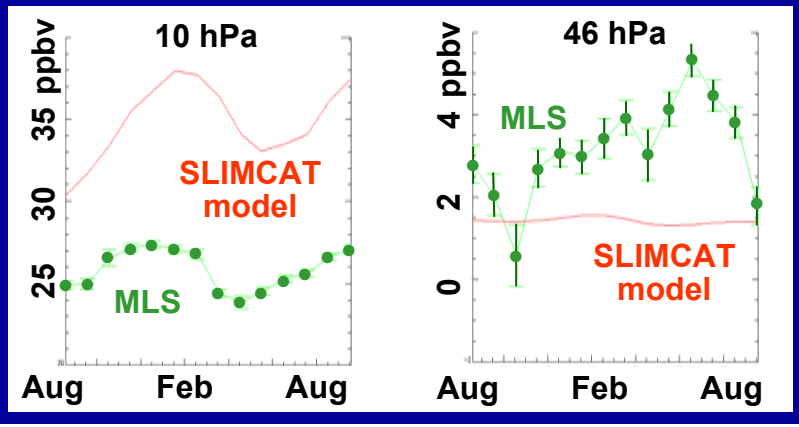

- **Solar-proton enhanced OH (and $HO_2$) in mesosphere seen in 4 events to date**
  - Associated $O_3$ loss also detected
  - See Pickett paper at this meeting

Enhanced mesospheric OH on 18 Jan 05



- **Now investigating annual cycle variation seen in OH**
  - Not yet sure whether observed variation at lowest altitudes (46 hPa) is real or is an artifact

Monthly zonal mean OH at equator



# Suite of Daily MLS Stratospheric Data

## Shown here in equivalent lat / potential temperature coords

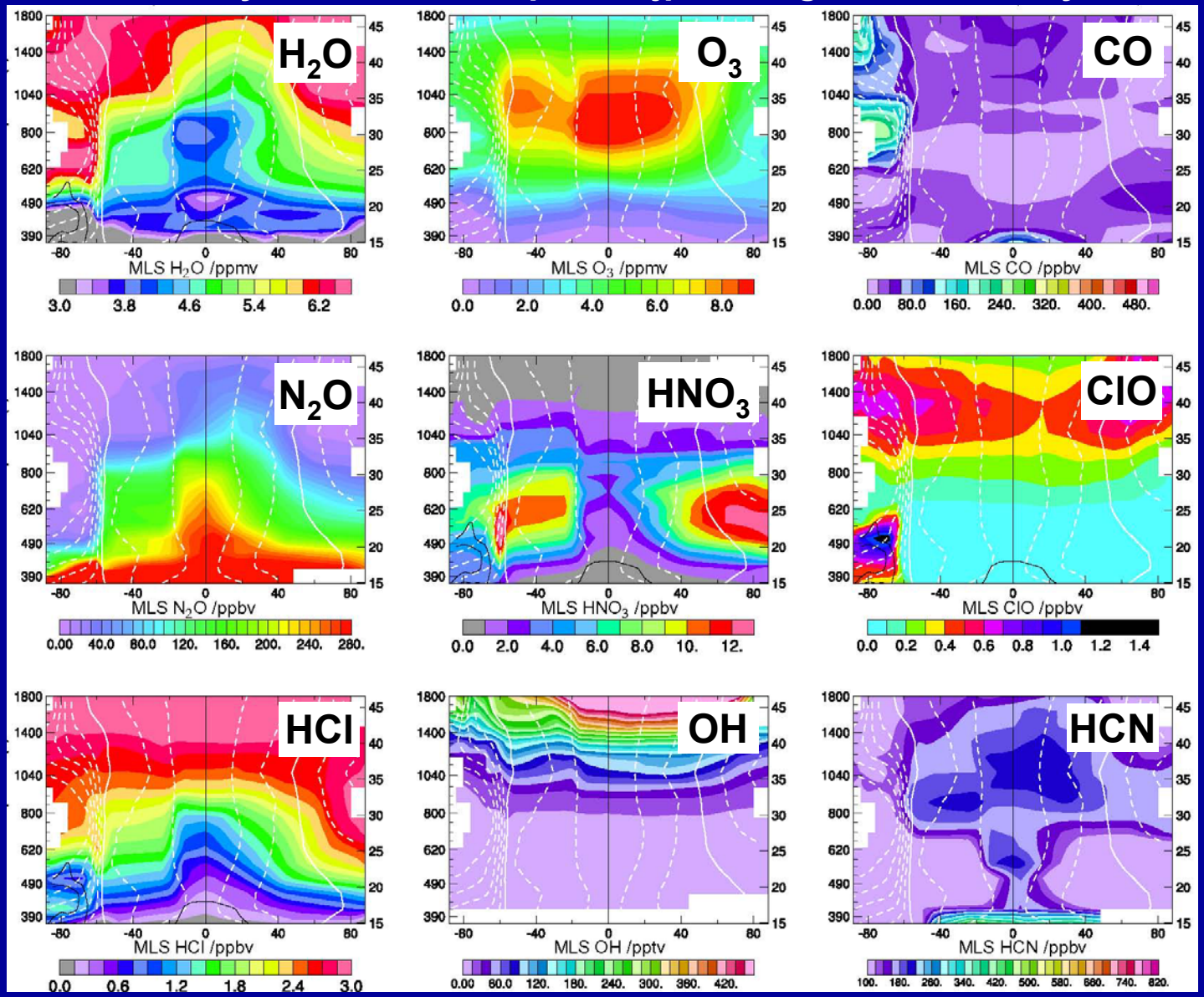
(plot by Gloria Manney, available at http://mls.jpl.nasa.gov for each day of data)

example here is for Sep 21 2005

vertical axis is potential temperature, from 390 K to 1800 K (~15-50 km)

horizontal axis is equivalent latitude, from 80S to 80N

white overlays are scaled potential vorticity

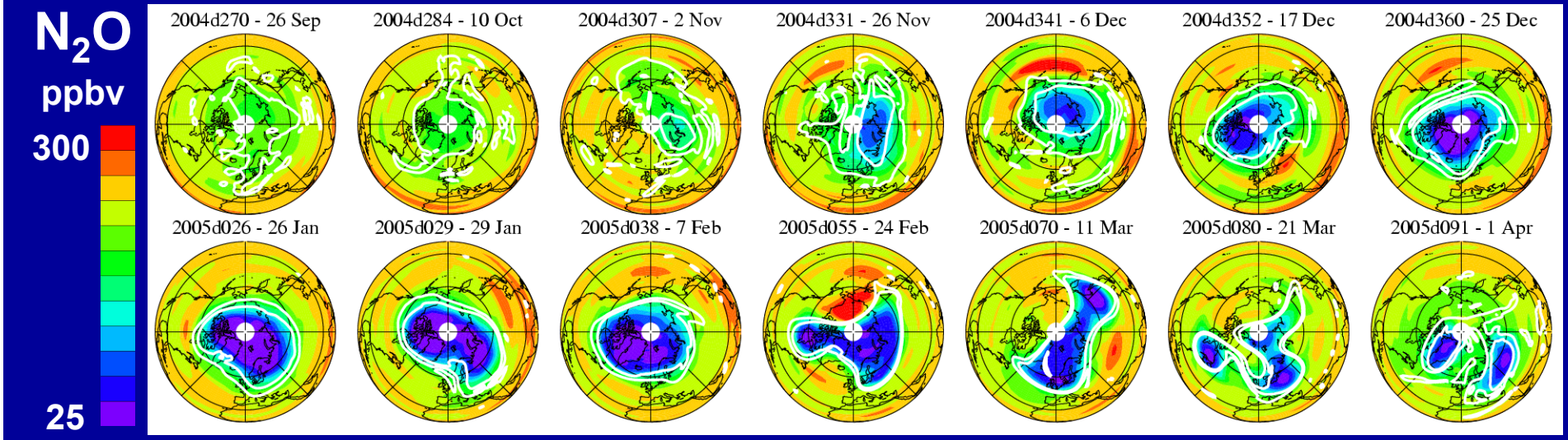


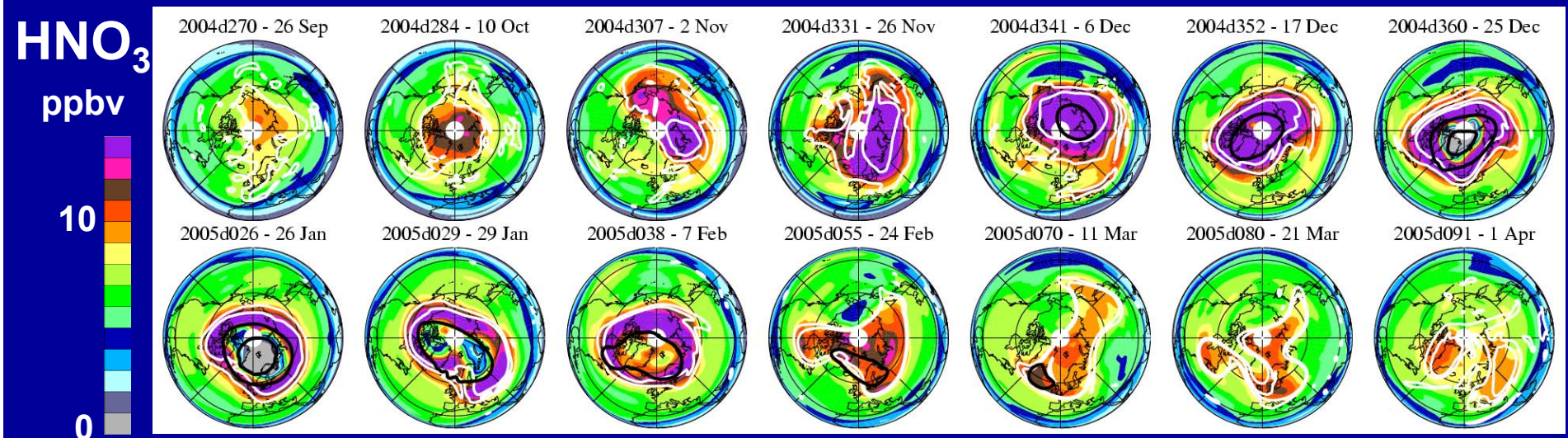
# Examples of $N_2O$ and $HNO_3$ data at θ = 490K

## Selected days: 26 Sep 2004 through 1 Apr 2005

**white contours are GMAO potential vorticity for vortex edge**

**(plots by Michelle Santee and Nathaniel Livesey)**

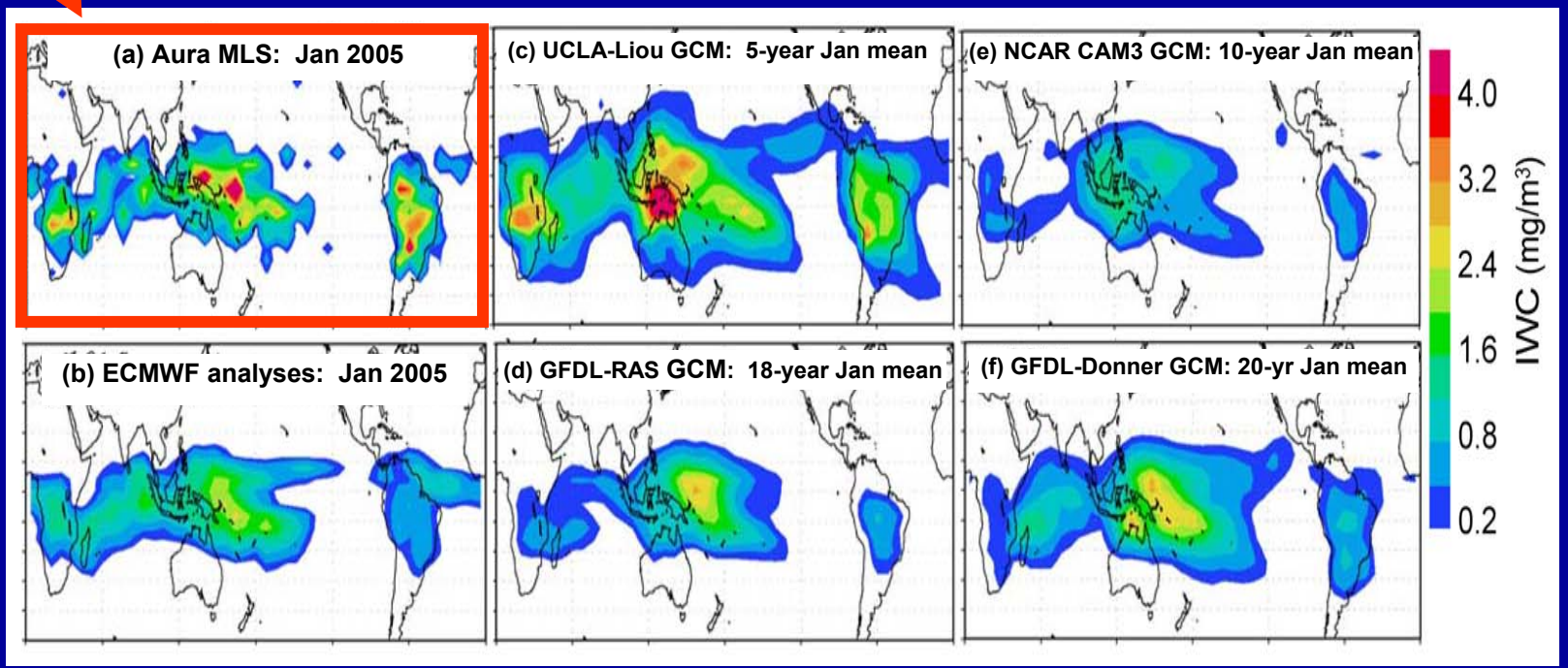


# MLS Cloud Ice Water Content (IWC) Data

- MLS IWC appears qualitatively correct, based on comparisons with
  (a) AIRS 'window' radiances (b) MODIS cloud optical depth, eff. radius
  (c) AMSU-B IWP, (d) ECMWF analyses (e) operational OLR
- Monthly-mean MLS IWC is thought quantitatively correct to a factor of 2, limited mainly by assumptions on ice particle size distribution
- Images below compare January means of IWC at 150 hPa from (a) MLS, (b) ECMWF analyses and (c-f) GCM climatologies

from J-F Li et al., GRL, vol. 32, L14826, 2005



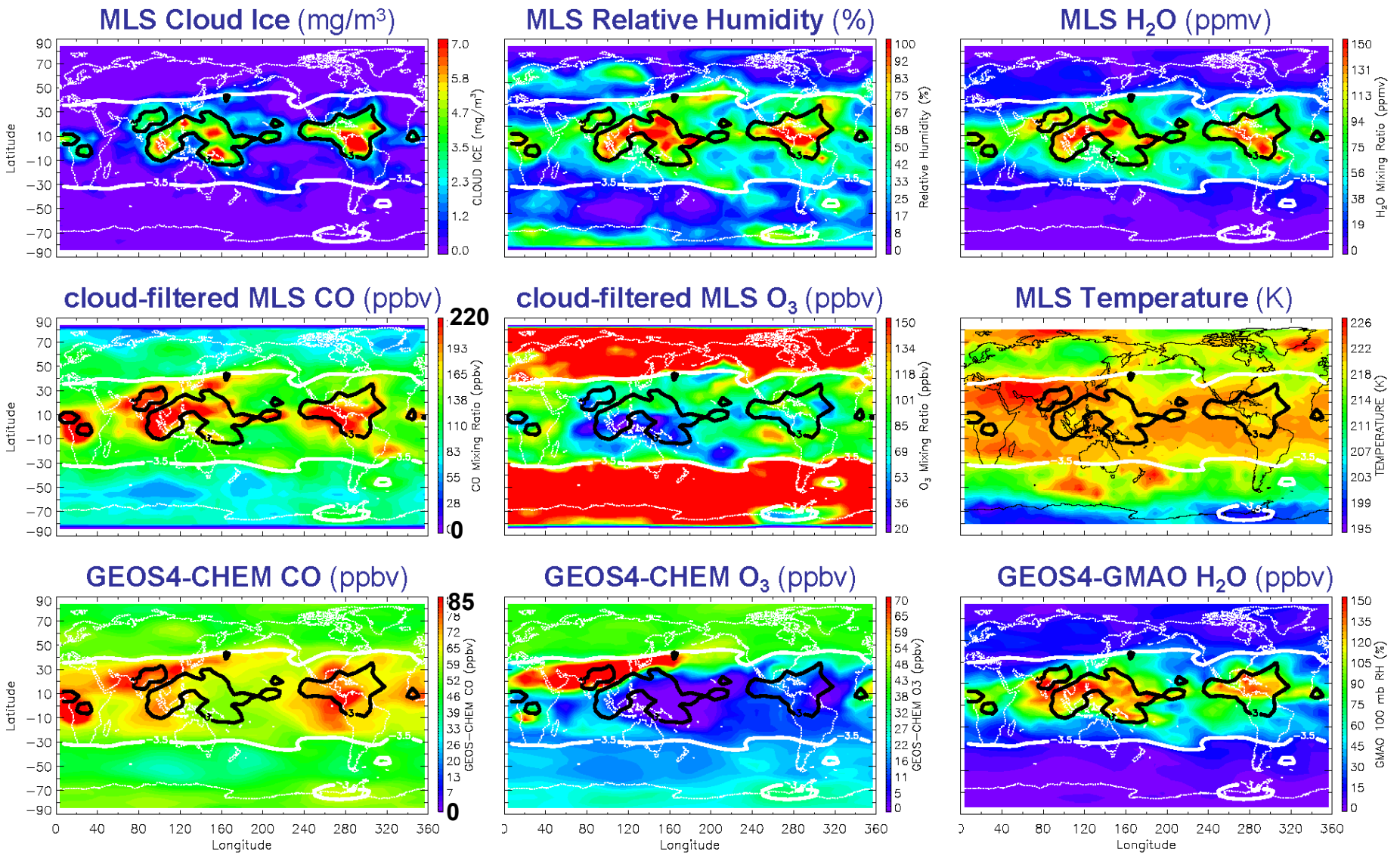
# MLS Upper Trop Data: 18-24 Sep 05 Weekly Map

## + GEOS-CHEM model for same time (from Qinbin Li)

white contour is GMAO tropopause PV; black is MLS cloud ice indicative of deep convection

(plots by Jonathan Jiang)

**maps here are for 215 hPa**



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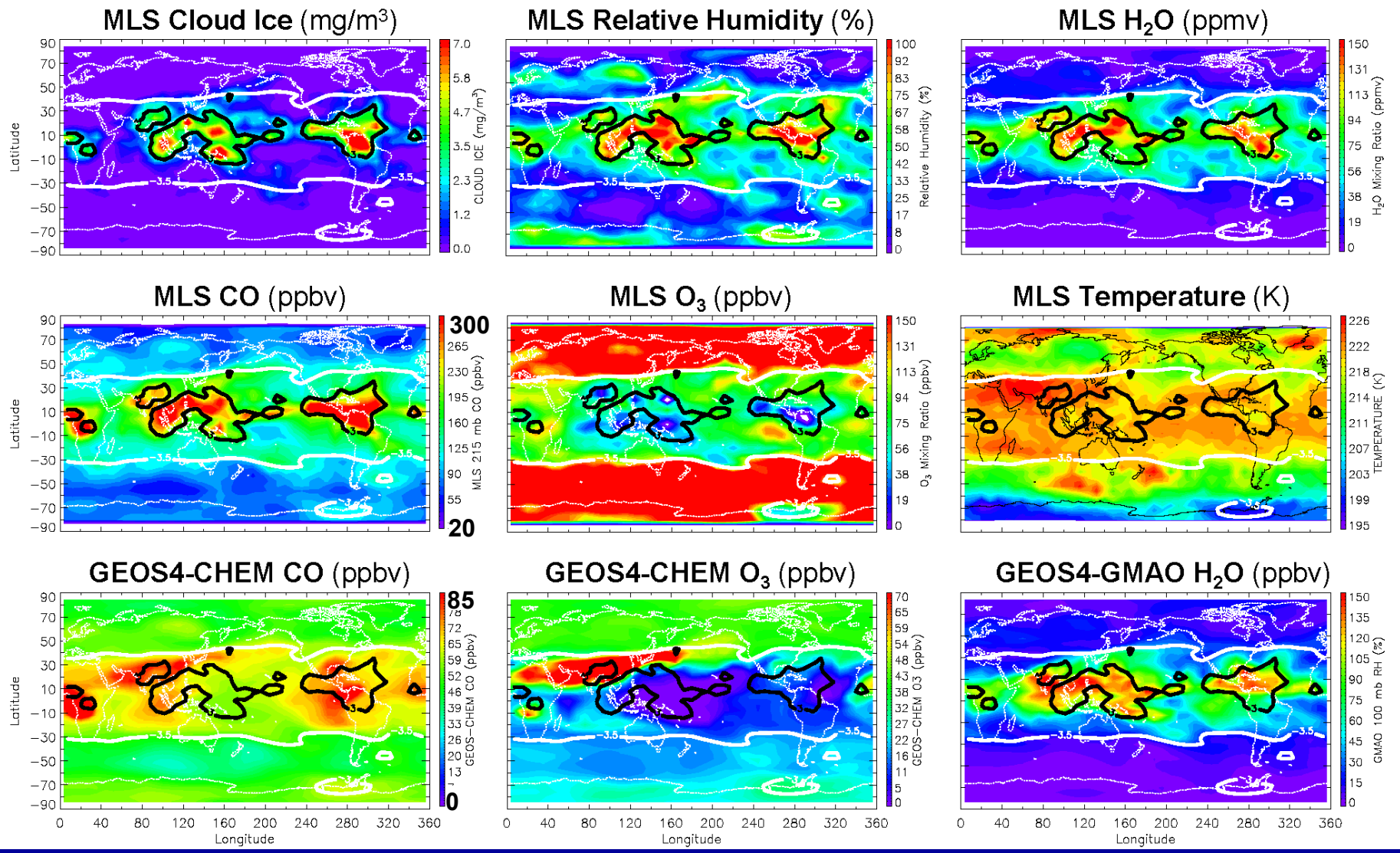


# MLS Data Product Summary

| data product | Status of Version 1.51 data | Priorities for Version 2 data<br>*green indicates highest overall priorities*<br>*blue indicates intermediate overall priorities*<br>*violet indicates low overall priority* |
|---|---|---|
| BrO | not useful | produce useful product |
| $CH_3CN$ | not produced as standard product | use better forward model, produce as standard product |
| ClO | validated for use per documentation | fix negative bias (~0.3 ppbv) at lowest altitudes |
| CO | problems in some regions | improve quality of upper trop data, fix vert. osc. in stratosphere |
| GPH | validated for use per documentation | fix high bias in 100 hPa reference level |
| $H_2O$ | validated for use per documentation | increase upper trop vertical grid to 12 levels per decade P |
| HCl | validated for use per documentation | fix small negative biases in winter vortex; extend vertical range |
| HCN | problems in some regions | use better a priori and forward model to improve product |
| $HNO_3$ | validated for use per documentation | if ~30% high-bias relative to IR is traced to MLS, fix it |
| $HO_2$ | validated for use per documentation | choose better parameter for smoothing versus precision |
| HOCl | problems in some regions | extend vertical range |
| ice | unvalidated, but thought useful | improve expected accuracy and vertical range; produce IWP |
| $N_2O$ | validated for use per documentation | improve convergence of retrievals in lowermost stratosphere |
| $O_3$ | validated for use per documentation | improve quality of data in upper troposphere |
| OH | validated for use per documentation | improve vertical resolution in mesosphere; improve lower strat product if further investigations on v1.5 indicate this needed |
| RHi | problems in some regions | improve, by using better vertical resolution of V2 $H_2O$ and T |
| T | validated for use per documentation | increase upper trop vertical grid to 12 levels per decade P |
| $SO_2$ | not in V1.51, but produced 'off-line' | produce as standard product |

# MLS Summary

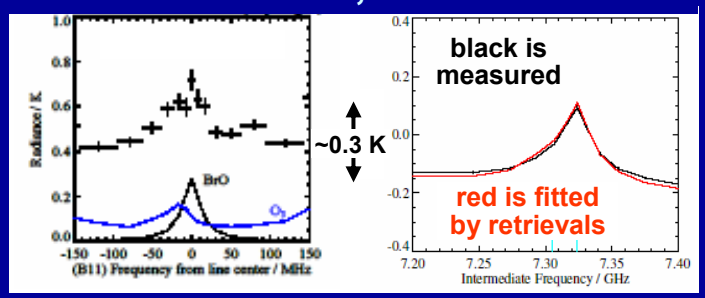
- **Instrument is performing excellently overall**
  - 1-2% radiometric calibration accuracy
- **High 'duty cycle' in producing good science data**
  - 98% overall since instrument operations stabilized on 11 Dec 2004
- **All Level 2 geophysical data for all of mission are publicly available**
  - Essential that users be familiar with MLS Data Quality Document
- **First phase of data validation has been completed**
  - Overview for 7 products in Froidevaux et al., IEEE Aura issue paper
  - Additional results in Sep 2005 Aura Validation Meeting presentations
- **Scientific results are starting to be produced**
  - Reprints/preprints of 9 GRL papers available at http://mls.jpl.nasa.gov


# Backup Charts

# MLS BrO data

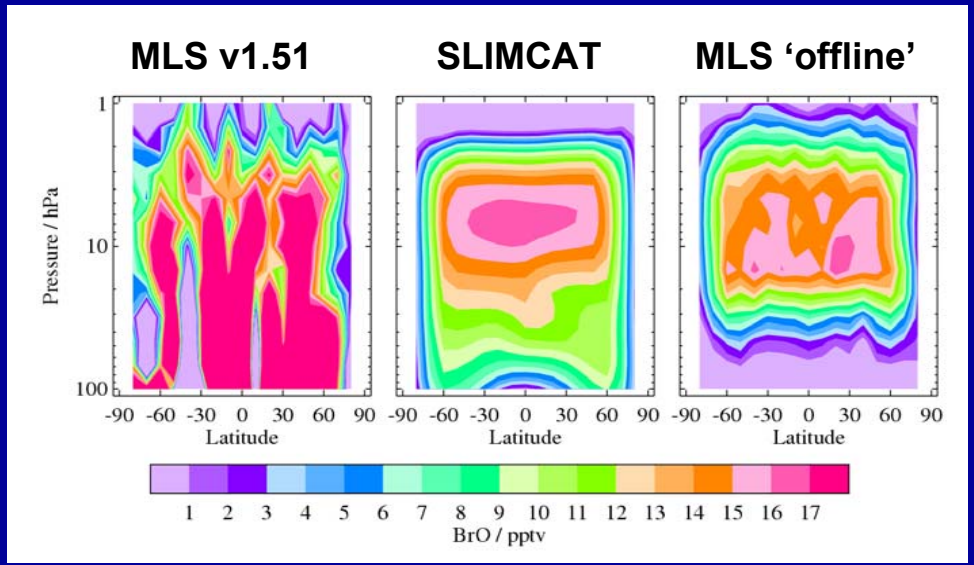
- **BrO is the most difficult MLS stratospheric measurement**
  - Averaging (e.g., monthly zonal means) is required to obtain useful S/N
  - MLS measures two BrO spectral lines, at 650.2 and 624.8 GHz
  - Examples of measured and fitted 650 GHz BrO line are shown at right
- **Version 1.51 BrO is <u>not</u> useful**
  - Oscillations in v1.5 retrievals
  - Version 2 will produce a useful product
- **An 'offline' retrieval is now producing useful data**
  - Mission-average results are shown at right, compared with v1.5 and SLIMCAT model

650 GHz BrO line, 30-40 km tan ht




Single day global average (left) and ±20° latitude mission average (right)

(figures by Nathaniel Livesey)



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